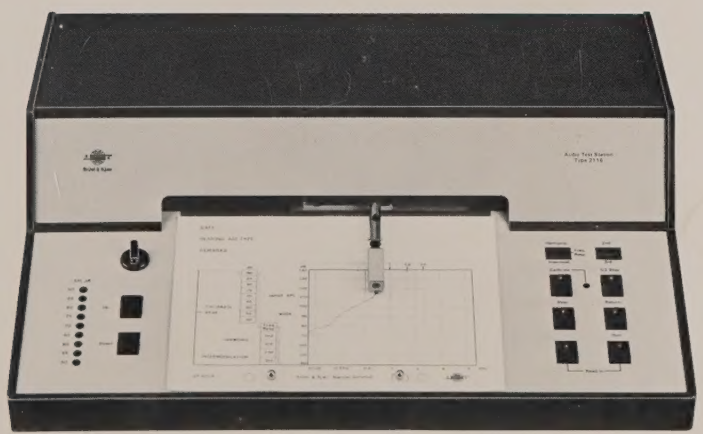
2116

C1355
S/N 916760

Instruction Manual

Audio Test Station Type 2116



The Audio Test Station Type 2116 is a combined generator, analyzer, and recorder primarily for swept frequency, harmonic distortion and intermodulation distortion analysis of hearing aids (to ANSI S.22-1976 and IEC R118) microphones, earphones, and bone conductors. Automatic regulation of the generator output level via a correction curve, pre-stored in a digital memory. A constant voltage output is also selectable. 100 Hz to 10 kHz frequency range. Dynamic range of 40 dB, selectable in 5 dB intervals, on the generator and 100 dB on the analyzer. Full digital control, easy-to-use keyboard, and simple operating procedure require minimum familiarisation period.

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AUDIO TEST STATION
TYPE 2116

(From serial No. 804077)

November 1979

This apparatus has been designed and tested according to Class I of IEC Publication 348, Safety Requirements for Electronic Measuring Apparatus, and has been supplied in safe condition. The present instruction manual contains information and warnings which should be followed by the user to ensure safe operation and to retain the apparatus in safe condition.

CONTENTS

1. INTRODUCTION AND SPECIFICATIONS (PRODUCT DATA) 1

2. CONTROLS 9

2.1. FRONT PANEL 9
2.2. REAR PANEL 10

3. PRELIMINARY 12

3.1. ENVIRONMENT 12
3.2. CONNECTING THE MAINS SUPPLY 12
3.3. CONNECTING THE MEASUREMENT TRANSDUCER 13
Connecting a Microphone 13
Connecting an Accelerometer 14
Connecting External Signal Sources 14
3.4. CONNECTING THE EXCITATION SOURCE 14
3.5. MOUNTING THE PEN 14

4. OPERATION 16

4.1. INTRODUCTION 16
4.2. CALIBRATION 16
Direct Acoustic Calibration using Calibrator or Pistonphone 17
Direct Vibration Calibration using Accelerometer Calibrator Type 4291 17
Direct Voltage Calibration using External Signal Generator 19
Indirect Calibration of Transducers using an External Signal Generator 20
4.3. GENERAL OPERATING PROCEDURE 20
Recording the Correction Curve 21
Performing the Measurement 21

5. USE WITH OTHER TEST APPARATUS 23

5.1. USE WITH THE ANECHOIC TEST CHAMBER TYPE 4222 23
5.2. USE WITH ARTIFICIAL EARS TYPES 4152 & 4153 23
5.3. USE WITH ARTIFICIAL MASTOID TYPE 4930 25

6. SERVICE AND REPAIR 27

type 2116

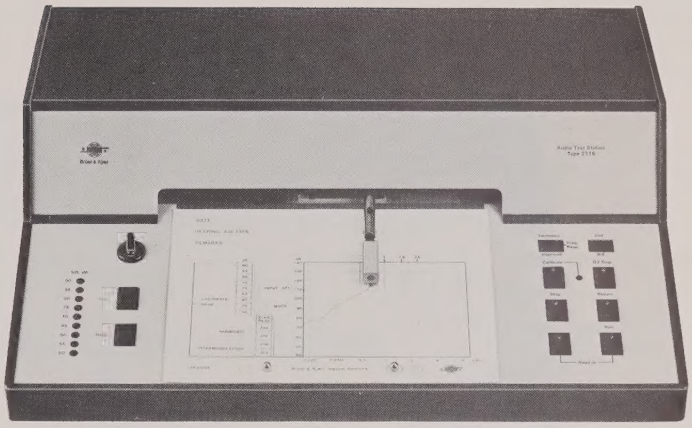
Audio Test Station

USES:

- Testing the frequency response, harmonic distortion and intermodulation distortion of hearing aids using the Anechoic Test Chamber Type 4222
- Measurement of loudspeaker characteristics
- Measurement of the sound insulation of hearing protectors
- Comparison measurements on bone vibrators using Artificial Mastoid Type 4930
- Measurements on microphones
- Reflection Measurements in Anechoic Chambers on Loudspeaker enclosures, Artificial Heads etc.
- Measurements on telephone earpieces using Artificial Ears Types 4152 or 4153

FEATURES:

- Three instruments, Signal Generator, Response Analyzer and Chart Recorder combined in one desk-top unit



- Automatic regulation of output signal level directly from a stored correction curve
- Wide frequency range from 100 Hz to 10 kHz in 256 logarithmically spaced discrete steps
- Output level adjustable over 40 dB range in 5 dB steps
- Measures both Intermodulation and Harmonic Distortion
- Full digital control
- Direct connection of either 1 inch or 1/2 inch microphones
- Test settings automatically indicated on test chart
- Measurements recorded on preprinted pre-punched chart for immediate documentation
- In accordance with IEC 118 and ANSI S3.22—1976
- Easy to operate
- Easily exchanged fibre pens available in three colours

Introduction

The Type 2116 Audio Test Station is a highly versatile, three-in-one instrument designed with special emphasis on simplicity of operation and clear presentation of results. The single desk-top unit is a careful integration of three separate sections; a signal generator which supplies a sinusoidal test signal to an external device e.g. loudspeaker or exciter; an analyzer which can measure harmonic and intermodulation distortion as well as frequency response, and a pen recorder for permanently documenting the results.

A built-in digital memory, a special feature of the instrument, enables a correction curve for the output signal to be pre-stored. Subsequent measurements can then be carried out with the excitation level held constant throughout the frequency range independently of the excitation source characteristics. This greatly eases interpretation of results and enables comparisons to be made from a common reference.

Previous methods of output level regulation often consisted of a feedback loop incorporating a supplementary transducer and amplifier as

Robust cabinet moulded in hard-skinned polyurethane foam.

Pre-printed chart on stiff card in A5 format (148 by 210 mm : 5,8 by 8,3 ins). Pre-punched holes locate chart accurately on the chart bed. Space for details of test object.

SPL selector determines test SPL. Light emitting diodes indicate selected sound pressure level.

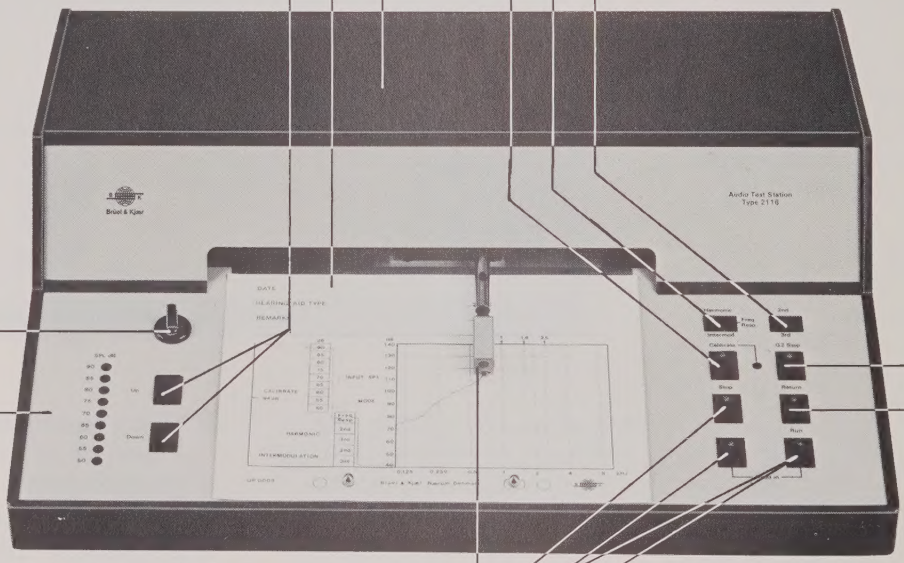
ON Switch

CALIBRATE switch and screwdriver adjusted potentiometer to calibrate the Microphone/Analyzer measurement chain.

Test mode switch. Selects "Harmonic", "Freq Resp", or "Intermod" test mode.

Selects "2nd" or "3rd" order distortion measurement.

G2 STOP switches off the 2nd generator in the INTERMOD mode, to ensure that a measured value is valid and not a product of circuit noise.



Angled control panel and chart bed for easy operation of the keys and a clear view of the curve.

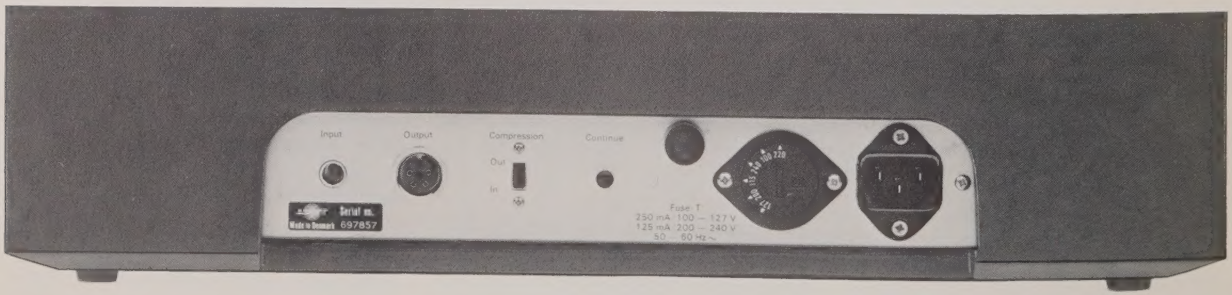
Disposable fibre pen, available in black, red or green.

STOP interrupts the sweep. RUN continues the sweep. Warning LED comes on if READ-IN process is prematurely halted because of insufficient attenuator range.

RETURN stops the sweep and returns the pen to the stand-by position. When operated during READ IN, sets that frequency as the upper limit to any subsequent sweeps.

RUN initiates the test for all measurement modes.

READ-IN switches must both be operated simultaneously in order to record a new correction curve. This is to avoid unintentional erasure.



Rear Panel

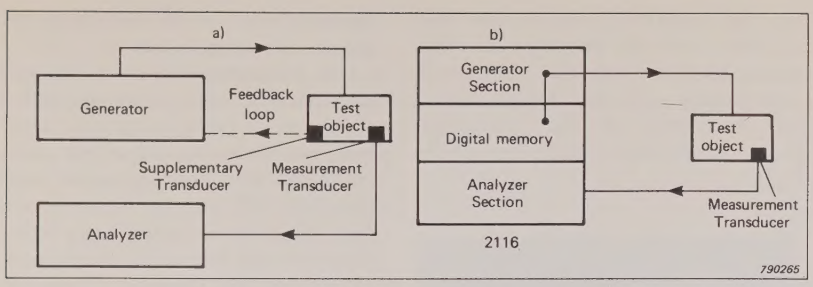


Fig.1. Constant excitation level can be achieved by a) a live feedback loop or b) a pre-stored correction curve as in the 2116

shown in Fig.1.a. The system employed in the 2116 however, avoids possible instability in the live feedback loop by pre-storing a correction curve, and simplifies the measurement set-up by using the measurement transducer itself. See Fig.1.b.

The 2116's versatility means that it can be used advantageously for a wide range of applications. It may be used with its built-in memory for measurements requiring regulation of the excitation signal e.g. on hearing aids, microphones, and hearing protectors, or without it to provide a constant voltage sinusoidal output for tests on loudspeakers, earphones, or bone vibrators. Moreover it may also be used to advantage just as an analyzer/recorder e.g. to check production item noise levels for quality control purposes.

Digital control from the central logic circuit, automatic recording of the response, and convenient control layout make the instrument particularly easy to operate, enabling valid measurements to be made after only a short period of familiarisation.

Use with Type 4222 Anechoic Test Chamber

Measurements on Hearing Aids

The evaluation of hearing aid performance is essential, both for matching the aid to a patient's hearing loss characteristics and for ensuring that it subsequently maintains that performance. Tests are necessary

1) at the factory as a quality control measure,
2) at the time of fitting
3) at regular subsequent intervals,
4) after repair, and
5) whenever the user feels that the aid is not performing adequately.

The Audio Test Station Type 2116 is primarily intended for use with the Anechoic Test Chamber Type 4222, essentially a small anechoic chamber with a built-in sound source, to carry out performance tests to IEC 118 and ANSI S3.22—1976. It may also be used over a limited frequency and dynamic range with the earlier Type 4212 Hearing Aid Test Box.

The following can be measured:
Swept frequency response
Swept 2nd and 3rd order harmonic distortion
Swept 2nd and 3rd order intermodulation distortion

The frequency response is necessary to match a hearing aid to the patient's hearing loss. The swept frequency response can be obtained over a range of test levels with the Type 2116 Audio Test Station.

Swept harmonic and intermodulation distortion measurements are both necessary to determine the extent of distortion which may not be adequately revealed by simple spot tests at a few fixed frequencies.

The following ANSI recommended parameters can be obtained using the above functions:

Saturation Sound Pressure Level Frequency Response Curve (SSPL90)
High Frequency Average Saturated Sound Pressure Level (HFAV SSPL90)
High Frequency Average Full On Gain
Frequency Response Curve at Harmonic Distortion
Equivalent Input Noise

Before measurements are begun the instrument must be correctly calibrated. This is easily accomplished using Sound Level Calibrator Type 4230 or Pistonphone Type 4220. The preamplifier of the Type 2116 is then adjusted until the pen indicates the calibration level, i.e. 94

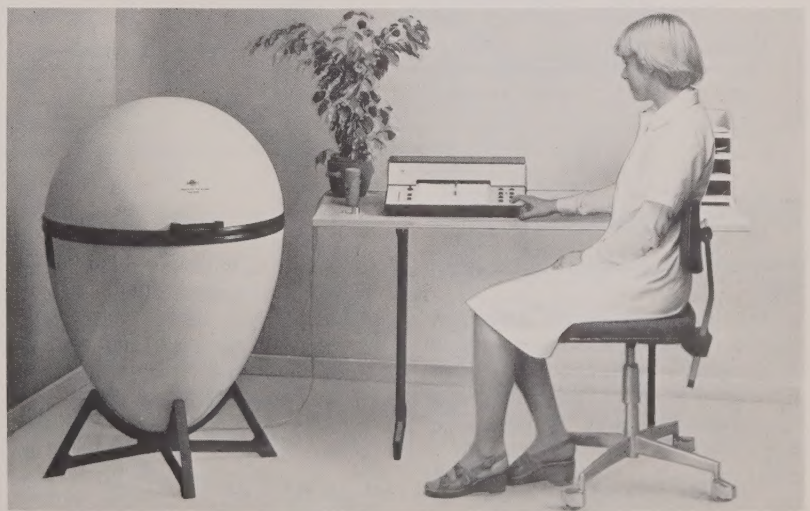


Fig.2. The Type 2116 in use with the Type 4222 Anechoic Test Chamber

or 124 dB respectively (re 20×10^{-6} Pa) on the chart. After calibration, the microphone assembly is laid on the test plane of the chamber so that a frequency sweep can be made to read in the correction curve, which compensates for the frequency characteristics of the test chamber.

At each frequency during the READ IN process the loudspeaker output is automatically regulated in 0,3 dB steps until a level of 90 dB is reached. The attenuation necessary to achieve this level at each frequency is then stored in a digital memory.

During this operation the pen is raised, but indicates progress by following the frequency along the top of the chart.

The instrument is now ready to make measurements on a hearing aid, which is connected to the microphone via a standard 2 cm^3 coupler. A suitable coupler for this purpose is the Type DB 0138, which meets both IEC and ANSI standards. All the items are then placed on the supporting net in the test chamber with the hearing aid in the same position that the measuring microphone originally occupied during recording of the correction curve, as shown in Fig.3.

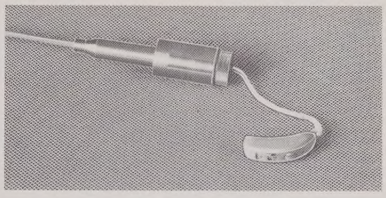


Fig.3. Hearing aid to be tested, coupler, and measuring microphone in place in the test chamber

The required measurement is carried out automatically at the selected level, and the response recorded on the chart, each measurement preceded by indication of level and parameter chosen. Typical measurement charts for a hearing aid worn behind the ear are reproduced in Fig.4. The different measurements are labelled for clarity on the figure but would normally be distinguished by using pens of different colours.

Measurement of the frequency response of microphones

The frequency response of small microphones, such as those used in telephone or communications handsets, can be measured simply using the Type 2116 and a suitable small anechoic test chamber such as the Type 4222. A correction curve to account for the frequency characteristics of the test chamber is first recorded in the memory of the 2116 using a Measuring Microphone Type 4144 (one inch) or 4134 (1/2 inch). During the subsequent test, the sound level in the measuring plane of the test chamber is kept constant by continuous reference to this stored correction curve, as for the testing of hearing aids.

The microphone to be tested is then placed in the same position in the chamber, in place of the measuring microphone, and its frequency response recorded directly on the chart. The frequency response of a typical monitoring microphone produced by this method is reproduced in Fig.6.

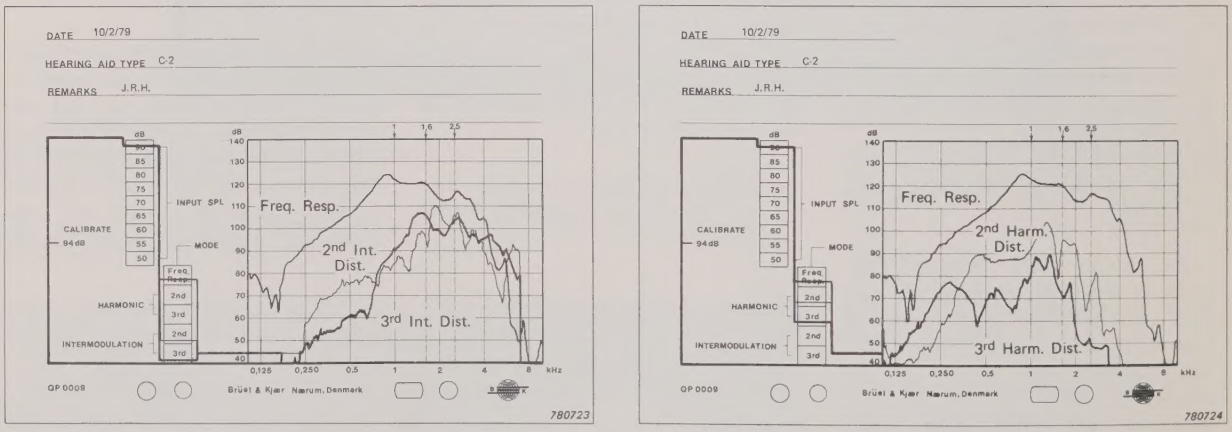


Fig.4. Complete set of hearing aid test curves

Other Applications

Frequency response of Bone Vibrators

Using the set-up of Fig.5 it is possible to make rapid tests on a bone vibrator, in order to check its characteristics against a standard curve for quality control purposes, or against a previous measurement in order to check on its performance in use. A constant voltage signal is obtained from the generator section of the 2116 to drive the bone vibrator which is mounted on the Artificial Mastoid Type 4930. The output from the transducer built into the Artificial Mastoid is fed to the analyzer section of the instrument. The resulting response curve is recorded automatically on the chart as before. A typical response curve is reproduced in Fig.7.

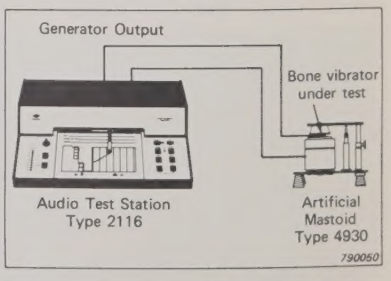


Fig.5. Arrangement using Audio Test Station and Artificial Mastoid Type 4930 for testing bone vibrators

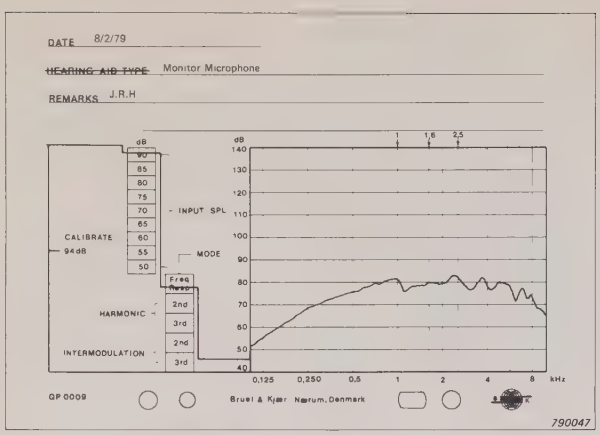


Fig.6. Typical frequency response of a monitor microphone at constant sound pressure level

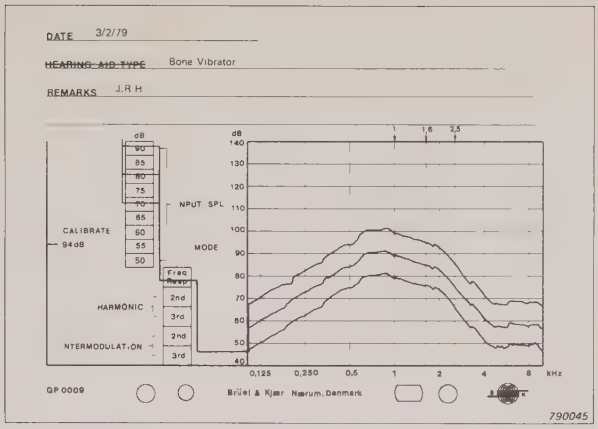


Fig.7. Constant voltage frequency response of a bone vibrator using Artificial Mastoid Type 4930

Measurements on Telephone earpieces

Fig.8 shows a simple measuring arrangement which enables the frequency response and distortion of telephone earpieces to be recorded automatically. The Generator section of the Type 2116 supplies a constant voltage signal to the earpiece to be tested, which is mounted on the Artificial Ear Type 4152 or 4153. The output from the microphone of the Artificial Ear is fed to the Analyzer section of the Type 2116 and the response curve recorded automatically on the chart. A 1/2 inch microphone Type 4134 is used with the Artificial Ear Type 4153 which is in accordance with IEC R318. A Type 4144 one inch Microphone is used in conjunction with the Artificial Ear Type 4152, for which a variety of couplers are available. An adaptor Type DB 0962 is required to fit the preamplifier to this artificial ear. Typical response curves for a range of input levels at constant voltage are shown in Fig.9.

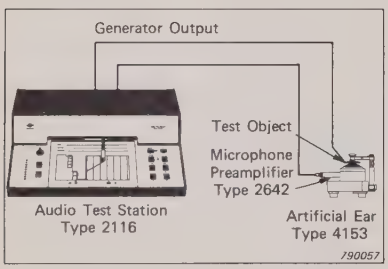


Fig.8. Use of the Audio Test Station with Artificial Ear Type 4153 to record the frequency response of telephone earpieces

General Quality Control Applications

The 2116 can also be used advantageously in situations which normally only require the frequency analyzer and recorder functions of the instrument, e.g. for noise control checks on items such as small electric motors and fans, where the frequency range of interest lies in the region above 500 Hz. (The BT product below 500 Hz is too small to obtain reliable results.) The resulting frequency spectrum is compared with a predetermined spectrum of limit levels against which the performance of the item is judged. The chart may be included with the tested item as an assurance of quality, or used as an aid to fault diagnosis in the event of a failure to achieve the stated specifications. A typical analysis is reproduced in Fig.10.

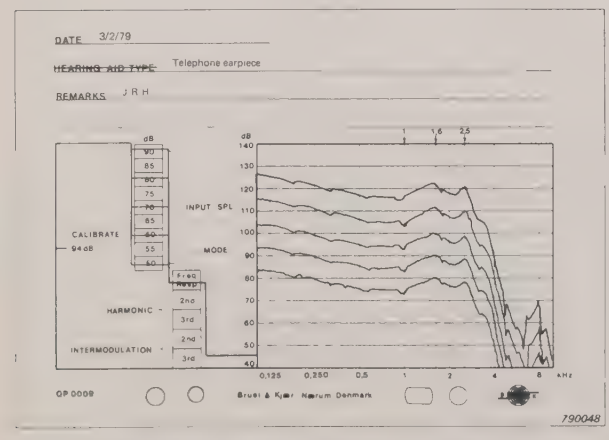


Fig.9. Constant voltage frequency response of a telephone earpiece for a range of input levels, recorded using the Artificial Ear Type 4153

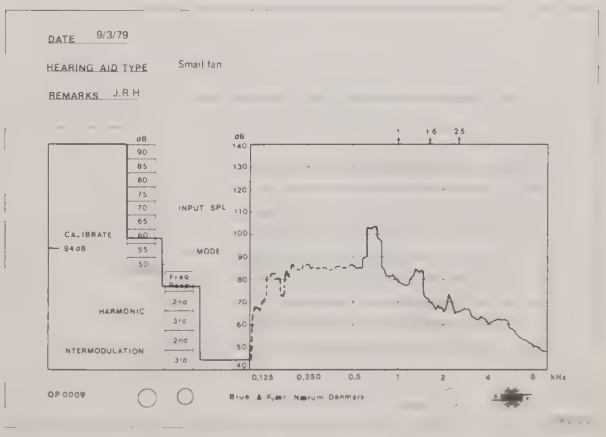


Fig.10. Noise output of a small fan recorded using the Audio Test Station

General Description and Method of Measurement

A block diagram of the instrument, clearly indicating its three main sections, is shown in Fig.11.

The Generator Section

The generator section consists of two sine generators with automatic attenuators, a summing amplifier to combine the signals, a manual attenuator to set the desired signal output level, and a power amplifier to drive the external load e.g. loudspeaker or small vibrator. The control logic circuit tunes the oscillator to sweep the test range in 256 discrete steps, each incrementing the frequency by 1,8%.

By continuous reference to the stored correction curve, the control logic adjusts the automatic attenuators at each step so that the output signal is maintained constant at its pre-selected level. Both the frequency and the level of the output signal are thus controlled automatically.

Only one oscillator is used in the "Read in", "Freq. Resp.", and "Harmonic" modes, but for intermodulation distortion measurements the outputs of both oscillators are summed, the amplitude of each signal being attenuated by 3 dB so that the resulting level corresponds to the value selected on the front panel.

A maximum of 3 Watts can be delivered into an 8 Ohm load with very low distortion.

The Analyzer Section

The measurement transducer is connected to the input preamplifier of the Audio Test Station, the sensitivity of which can be adjusted over a 20 dB range to accommodate variations in the sensitivity of the measuring chain. After the adjustable amplifier, the signal is passed to the bandpass filter, which is preceded and followed by autoranging amplifiers which automatically select the best possible dynamic range. The filter is a six pole, 15% Butterworth type, controlled digitally from the logic circuit. The 100 Hz to 10 kHz measurement range is covered by 64 frequency bands, each filter step covering 4 oscillator tuning steps, of which there are 256. The filter may be bypassed in the "Calibrate" mode.

The following logarithmic Mean Square Detector gives a DC output, proportional (in dB) to the RMS value of the filter input signal, which is then combined with correction signals from the autoranging amplifiers to give a DC signal proportional to the measured signal level at the transducer.

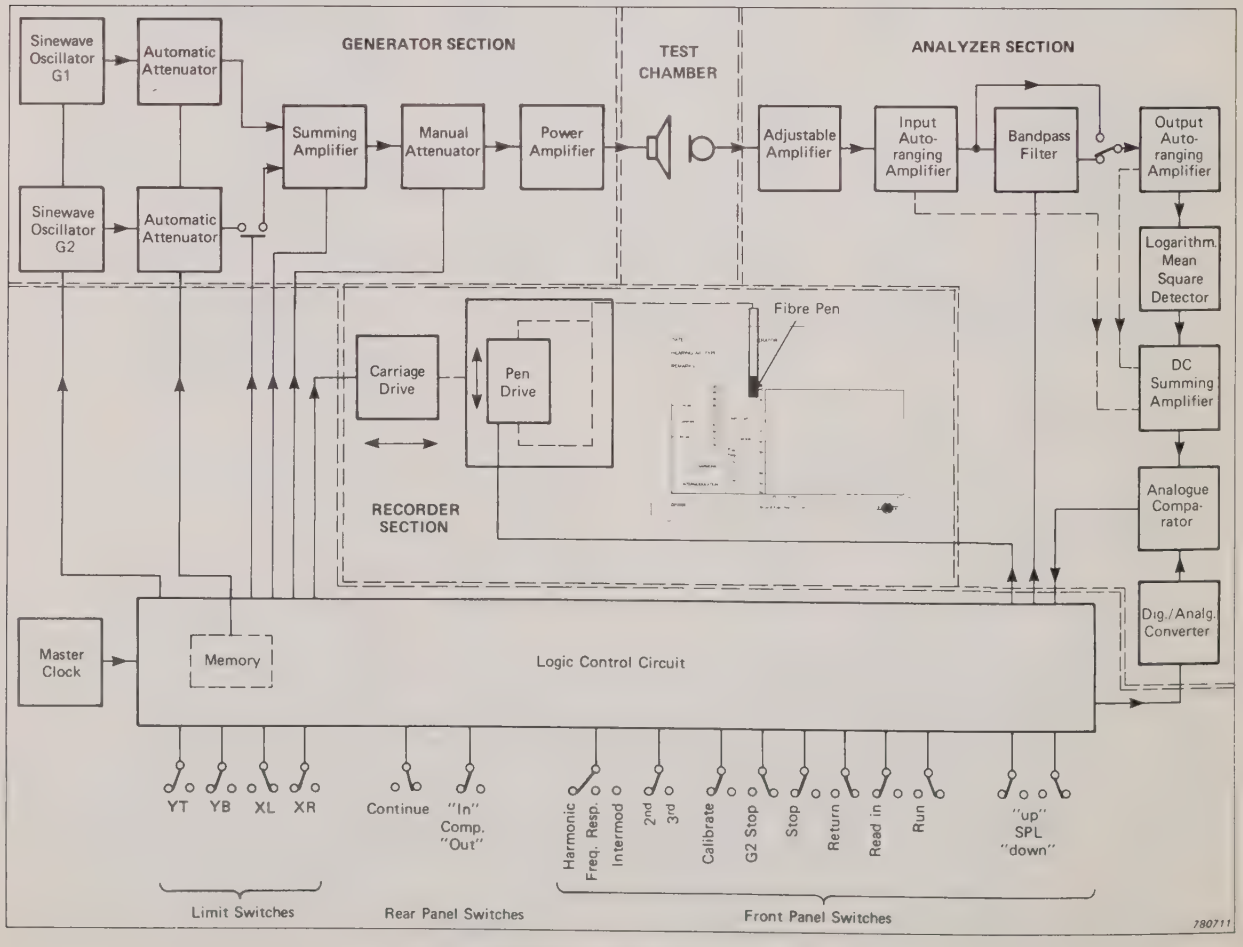


Fig.11. Simplified block diagram of the Type 2116

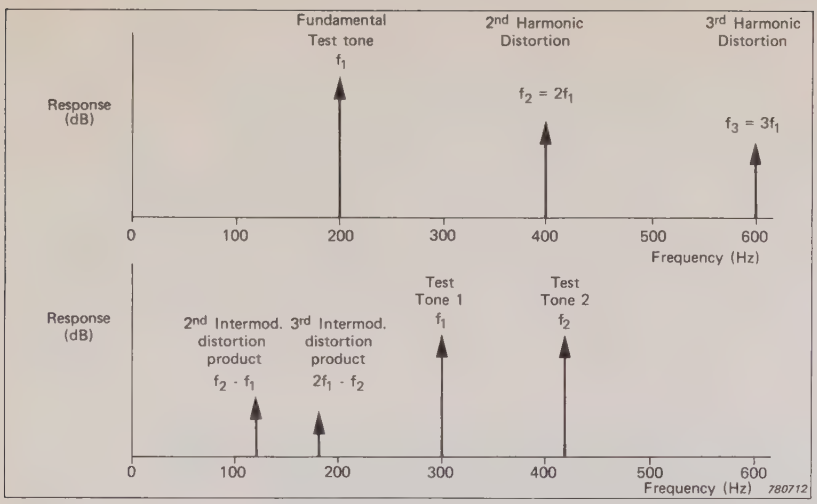


Fig.12. Harmonic distortion (upper) and intermodulation distortion (lower)

In the Analogue Comparator this is compared with a signal defining the current pen position, the difference signal being fed to the pen recorder Y-axis drive.

Three Measurements are Available:

Frequency Response:

With the "Freq. Resp." parameter selected, the output signal can be adjusted in steps of 5 dB using the switches "Up", "Down", the chosen level being indicated by an LED. Depressing RUN initiates a measurement, and the pen marks the card with the measurement parameter and the output level chosen. When the pen reaches 100 Hz the output signal is switched on and the sweep continues automatically to 10 kHz. On completion, the pen is returned to the standby position ready for a further measurement.

Harmonic Distortion

Harmonic distortion is the signal which a single pure tone produces in a non-linear circuit at frequencies which are integral multiples of the frequency of the original tone. The distortion order is the same as the harmonic number, as shown in the upper figure of Fig.12.

In the HARMONIC mode, either 2nd or 3rd order distortion measurement can be selected, with the output signal level preset as required.

The analyzer filter tunes in to the selected harmonic, and the distortion amplitude is then recorded on the chart, using the *fundamental,* i.e. the frequency of the source tone, as a reference along the frequency axis.

Measurement begins when the pen indicates 100 Hz and stops automatically when the *filter* reaches 10 kHz.

Intermodulation Distortion

Intermodulation distortion occurs when two tones at different frequencies are input to a circuit with non-linearities.

The resulting signal at the output consists of the primary tones and a number of distortion products with different frequencies and amplitudes given by

$$A_{p,q} \sin 2\pi \left(\pm pf_2 \pm qf_1\right)t$$

where p and q are integer numbers and f_1 and f_2 are the test tone frequencies. The distortion order is the result of adding p and q. The distortion components at a higher frequency than the primary tones, soon fall outside the operating frequency range of audio equipment and are rapidly attenuated as its frequency response falls off. Of more interest are the distortion products lower than the primary tones, which lie within the frequency range of audio equipment and therefore give a more realistic measure of the influence on audio quality of intermodulation distortion. As shown in the lower figure of Fig.12, the measured 2nd order intermodultion component occurs at a frequency of $f_2 - f_1$ and the 3rd order component occurs at $2f_1 - f_2$.

In the "Intermod" mode either the 2nd or 3rd intermodulation distortion product can be selected. The output signal level, in this case the sum of two pure tones, is predetermined using the "SPL" selector. The frequency relationship between the 2 primary tones is pre-determined at a fixed ratio of 1:1,4, which ensures that the distortion products are within the frequency range. The 2nd order distortion product is thus measured at $0,4f_1$, and the 3rd order product at $0,6f_1$ where f_1 is the frequency of the lowest primary tone.

Pen Recorder

Both pen and carriage drives are the stepping motor type, under the control of the logic circuit.

For the Y-axis deflection this supplies digital information about the current pen position to a Digital to Analogue converter. The converter output, which is proportional to the pen position, is compared with the analyzer DC signal, the difference signal controlling the pen.

For the X-axis deflection the carriage drive is controlled by the logic circuit by continuous reference to the number of generator frequency step increments.

The chart is visible throughout the measurement. Results are recorded on a pre-printed chart of stiff white card in A5 format (148 by 210 mm : 5,8 by 8,3 in).

The axes are chosen so that 20 dB on the response (vertical) axis corresponds to one octave on the frequency (horizontal) axis, in accordance with international agreements for audiometry. When a measurement is started, the level and the parameter chosen are recorded automatically on the chart before the measurement proceeds.

There is no need for the operator to intervene at any stage or make routine notes about the measurement conditions. Space is provided for details of the test object, and the other side is pre-printed with the single value parameters recom-

mended by ANSI standards for measurements on hearing aids. Prepunched holes locate it accurately on the chart bed, and also enable it to be filed in binders to both European and U.S. standards. Charts are available in packages of 250 under the order number QP 0009.

Mechanical Design

The mechanical design of the instrument is simple and robust. The carriage which supports the writing system and the pen drive itself are both driven by stepping motors via toothed belts. This method minimises mechanical coupling and vibration transmission. The motor bearings and other moving parts are self-lubricating for long trouble-free service.

Microphone Power Supply

The preamplifier is connected via a 5 pin socket on the rear of the instrument carrying both the preamplifier supply voltage (28 V) and the 200 V microphone polarization voltage. The Microphone Type 4134, which is screwed directly to the Type 2642 Preamplifier, is connected to the coupler DB 0138 via an adaptor ring DB 0225. The 1 inch Microphone Type 4144 fits directly to the coupler but must be connected to the Preamplifier via an adaptor DB 0962. The Ear Simulator Type 4157 has a Microphone Type 4134 built in, and connects directly to the Preamplifier. See Fig.13.

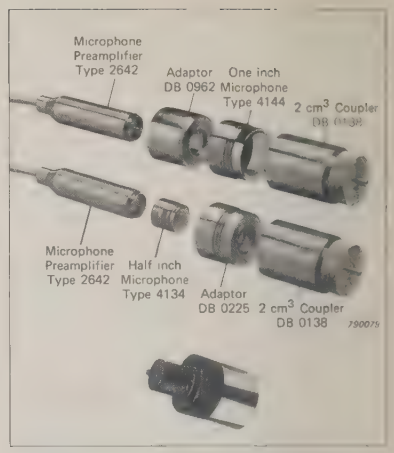


Fig.13. Microphones, Preamplifier, Coupler with adaptors, and Ear Simulator Type 4157

Specifications 2116

Input Section:

Frequency Range: 100 Hz to 10 kHz

Dynamic Range: 100 dB with automatic range switching

Measuring Range: 25 μV to 2,5 V with input sensitivity of approximately 0 dB

With microphone of nominal sensitivity 12,5 mV/Pa: 40 to 140 dB SPL

With accelerometer of nominal sensitivity 1 mV/ms^{-2}: 25 mms^{-2} to 2,5 kms^{-2}

Sensitivity Adjustment: —14 to +4 dB preset potentiometer

Input Impedance: 100 kΩ — direct. 1 GΩ || 3 pF via Microphone Preamplifier Type 2642 supplied

Max. Input Voltage: 4,5 V peak

Preamp. Supply Voltage: +28 V output via 10 kΩ

Mic. Polarization Voltage: +200 V output via 100 kΩ

Analyzer Section:

Bandwidth (—3 dB): 15% of filter centre frequency

Centre Frequency: Automatically stepped in 7% increments from 100 Hz to 10 kHz

Minimum Measurable Distortion: 1%

Sweep Speed: Automatic - depends on signal analyzed

Detector Characteristic: RMS

Time Constant: 50 ms

Recorder Section:

Modes and Test Duration (typical):

Frequency Response	40 s
Harmonic Distortion (2nd and 3rd)	30 s
Intermod. Distortion (2nd and 3rd)	30 s
Amplitude Correction (Read-in)	35 s
Pen Return	14 s
Measuring Parameter Indication	9 s

Chart Size: A5 (DIN) size —148 by 210 mm (5,8 by 8,3 in)

Writing Area: 80 by 105 mm (3,2 by 4,2 in)

Pens: Disposable fibre pens. Colour green, red or black

Generator Section:

Output Signal: Single sine tone with frequency automatically stepped in 1,8% increments for frequency response and 2nd and 3rd harmonic distortion records

Two sine tones with fixed frequency displacement of 1 to 1,4 automatically stepped in 1,8% increments for 2nd and 3rd intermodulation distortion records

Max. Output: 5 V (1 A) RMS giving 3 VA into 8Ω load

Amplitude Control: Manual control from 0 to —40 dB in 5 dB steps

Automatic correction from 0 to —38,1 dB in 0,3 dB steps

Environmental Conditions:

Temperature: +5 to +40°C (+41 to +104°F) operating

—10 to +50°C (+14 to 122°F) storage

Humidity: 0 to 90% relative humidity without condensation

Power Requirements:

100, 115, 127, 200, 220 and 240 V AC ±10% (50 to 60 Hz), 27 VA. Complies with safety Class I of IEC 348

Dimensions:

Height:	142 mm (5,6 in)
Width:	420 mm (16,9 in)
Depth:	320 mm (12,9 in)

Weight:

6,5 kg (14,3 lb)

Accessories Included:

1 Microphone Preamplifier Type 2642

1 1/2 inch Condenser Microphone Type 4134

1 1 inch Microphone Adaptor	DB 0962
Pack of 250 Recorder Charts	QP 0009
6 Fibre Pens (2 black, 2 green, 2 red)	QI 0003
1 4 pin Generator Output plug	JP 0402

Instruments and Accessories Available:

Anechoic Test Chamber Type 4222

Sound Level Calibrator Type 4230

Pistonphone Type 4220

1 inch Condenser Microphone Type 4144

2 cm3 coupler in accordance with IEC R126 - 1961 and ANSI S.3.7 - 1973 DB 0138

Ear Simulator Type 4157

Adaptor for mounting 1/2 inch Microphone on DB 0138 coupler DB 0225

Set of 6 black fibre pens QI 0004

Set of 6 red fibre pens QI 0005

Set of 6 green fibre pens QI 0006

2. CONTROLS

2.1. FRONT PANEL

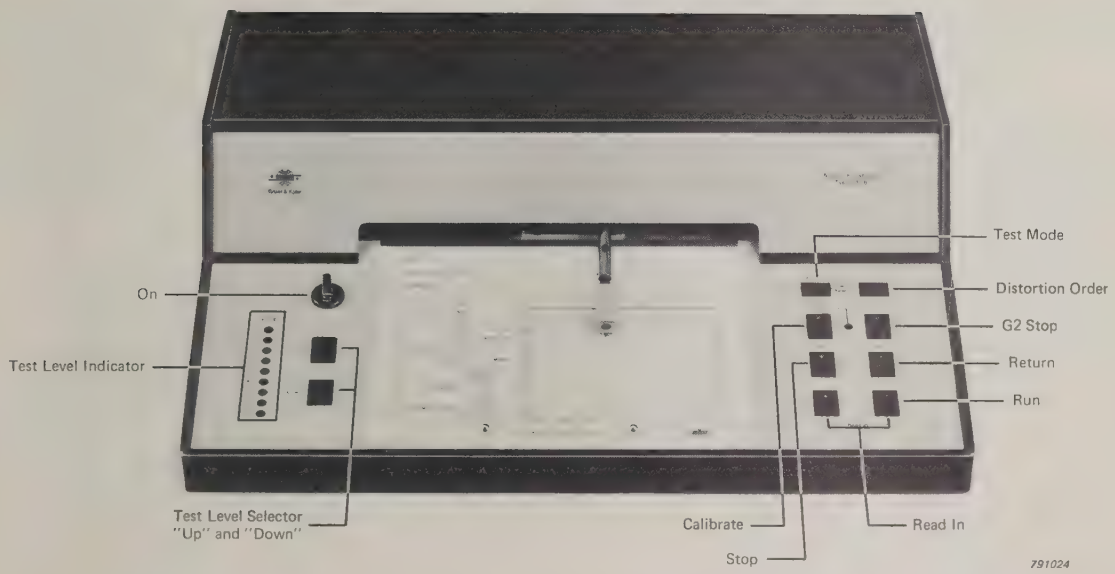


Fig.2.1. Front Panel Layout

ON: Toggle switch for mains power. When switched on, one of the row of light emitting diodes, labelled SPL dB, below and to the left of the switch will light. To the right of the chart the LED in the RETURN push-key will light and that of the left READ-IN pushkey will flash.

SPL dB: Displays the selected sound pressure level at which the subsequent measurement takes place.

UP: Increases the selected test level by one 5 dB increment each time it is pressed.

DOWN: Decreases the selected test level by one 5 dB increment each time it is pressed.

TEST MODE: Three position switch to select the test parameter; "Harmonic", "Freq. Resp." or "Intermod."

DISTORTION ORDER: Selects 2nd or 3rd order distortion when TEST MODE is in either "Harmonic" or "Intermod." position. Inoperative when TEST MODE is in "Freq. Resp." position.

The following six pushkeys all incorporate a light emitting diode which lights when the switch is active.

CALIBRATE: Pushkey which causes the pen to indicate the signal level (linear from 100 Hz to 10 kHz) at the input along the left-hand edge of the chart. To the right of the switch is a screwdriver-operated sensitivity adjustment potentiometer.

G2 STOP: When pressed, temporarily switches off the 2nd (higher frequency) component of the compound signal when the TEST MODE switch is in the "Intermod" position, to check that the measured signal is really due to intermodulation distortion and not to circuit noise. Releasing the pushkey reconnects the test tone.

STOP: Interrupts the test sweep until either RETURN, which ends the test and returns the pen, or RUN, which continues the test, is pressed. Has no effect during READ-IN process.

RETURN: When operated in READ-IN mode the sweep is stopped and the pen is returned. All subsequent test sweeps are terminated at the frequency reached. When operated during a test, returns the pen to the stand-by position, abandonning any measurement in progress.

RUN: Starts a measurement or the correction curve read-in process. Continues a test sweep after operating STOP during a measurement.

READ IN: Both pushkeys must be operated, simultaneously, the left before the right (RUN) in order to record a new correction curve.

To record a correction curve the "Compression" switch on the rear panel must be in the "in" position.

2.2. REAR PANEL

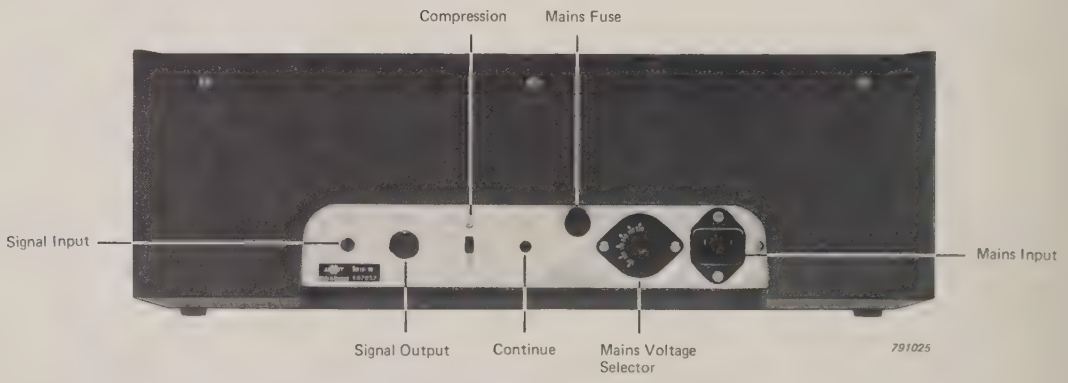


Fig.2.2. Rear Panel Layout

INPUT: 5-pin socket to accept plug (B & K No. JP 0510) from the microphone and preamplifier lead. For connections see Fig.3.2.

OUTPUT: 4 pin DIN socket to accept plug (B & K No. JP 0402) for connection of external excitation, loudspeaker etc. For connections see Fig.3.6. Max. Voltage: 10 V, max. current: 600 mA.

COMPRESSION: Slider switch to select the automatic level compensation ("In"). When "Out" is selected, a constant output voltage is obtained. (0,25 V ±2 dB nominal at an SPL setting of 90 dB). When using the instrument as an analyzer without employing the digital memory to store a correction curve, this switch must be in the "Out" position.

Note: During READ IN, this switch must be in the "in" position to be able to record a correction curve.

CONTINUE: Microswitch which disconnects the memory of the instrument when pressed, and kept pressed, during READ IN. No valid correction curve is stored until the switch is released again.

FUSE: Slow blow mains fuse for protecting the instrument. For fuse selection see section 3.2.

MAINS VOLTAGE SELECTION: For selecting correct mains voltage setting, see section 3.2.

MAINS INPUT: For connection of the mains supply. Before connecting a supply, the voltage setting and fuse checks should be carried out as in section 3.2.

⚠ **WARNING:** The 2116 is designed to be operated with its signal ground lines and chassis always at earth potential. Never let the signal ground terminals, socket screens or chassis float at any other potential, as this will impair the operating safety of the 2116 and may damage the instrument.

3. PRELIMINARY

3.1. ENVIRONMENT

The instrument is intended for desktop use in a normal factory, office, or clinic environment in temperatures between +5°C and 40°C and up to 90% humidity without condensation.

3.2. CONNECTING THE MAINS SUPPLY

Before connecting a mains supply, the following checks and adjustments should be carried out to ensure safe operation of the instrument.

Mains Voltage Setting

The 2116 may be operated from 100, 115, 127, 200, 220 or 240 V AC, ±10%, 50 to 400 Hz. The VOLTAGE SELECTOR is on the rear panel. To select the correct mains voltage setting, insert a widebladed screwdriver or small coin into the slot provided and turn until the correct voltage setting is indicated by the arrow at the top of the fixed rear plate.

Mains Fuse Rating

When used with a voltage from 100 V to 127 V, a slow blow (Type T) fuse with a rating of 250 mA should be used; with voltages from 200 V to 240 V AC, a slow blow fuse of 125 mA should be used.

Make sure that only fuses with the required rated current and of the specified type are used for replacement. The use of mended fuses and the short circuiting of fuse holders is prohibited.

Mains Input Connection

Once the mains voltage setting and fuse have been checked, the mains supply may be connected to the MAINS INPUT socket of the apparatus using the Power Cable AN 0010 provided. To fit a suitable mains plug to the cable see Fig.3.1.

For maximum operating safety the protective (green/yellow) conductor of the power cable should be connected to a suitable earth, such as the protective earth contact of a mains socket outlet. The use of extension cables without protective conductor shall be avoided.

In countries where the use of mains socket outlets without protected earth conductor is standard, the mains supply should incorporate an authorised earth leakage circuit breaker.

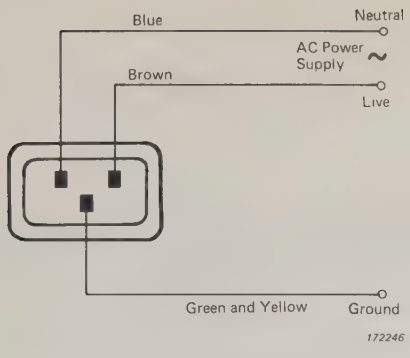


Fig.3.1. Mains Input socket, external view

3.3. CONNECTING THE MEASUREMENT TRANSDUCER

Connection of the Preamplifier is via a miniature 5-pin socket on the rear panel of the instrument. The corresponding plug has spring catches to lock it to the socket. To remove the plug it must be held by the outer ring, which slides back when pulled, releasing the catches and allowing the plug to be withdrawn. Pulling the rear portion of the plug, or the cable, will not release these catches and the plug will remain locked in place.

If the length of the transducer cable is insufficient, it may be extended by using extension cable AO 0175 (3 m). Fig.3.2 shows the pin connections.

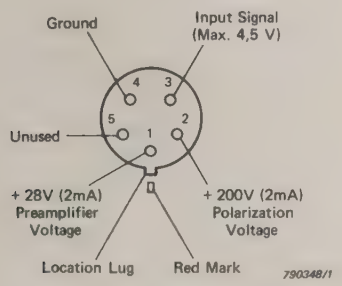


Fig.3.2. Pin connections of the INPUT socket viewed looking into the socket or from the soldering side of the corresponding plug

3.3.1. Connecting a Microphone

A Brüel & Kjær half inch microphone such as the type 4134 screws directly to the Type 2642 Preamplifier. A one inch microphone e.g. Type 4144 requires an adaptor DB 0962 as shown in Fig.3.3.

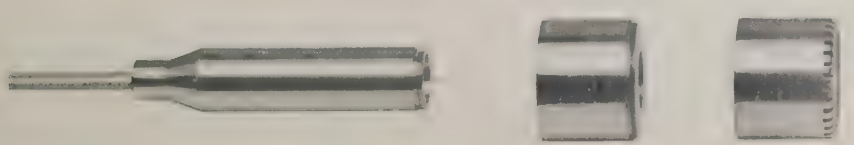


Fig.3.3. Half inch to one inch adaptor DB 0962 for mounting a one inch microphone to the Preamplifier Type 2642

3.3.2. Connecting an Accelerometer

Special adaptors JJ 2614 and JP 0028 required to connect the miniature plug of the accelerometer cable to the Preamplifier Type 2642 as shown in Fig.3.4. The adaptor JP 0028 is supplied with accelerometer sets.

Fig.3.4. Connecting an accelerometer to the Preamplifier Type 2642 using special adaptors JJ 2614 and JP 0028

3.3.3. Connecting External Signal Sources

An adaptor JJ 2614 allows an external source, such as a sinewave generator or output from an accelerometer preamplifier for example, to be connected via a standard B & K plug to the Type 2642 Preamplifier. See Fig.3.5.

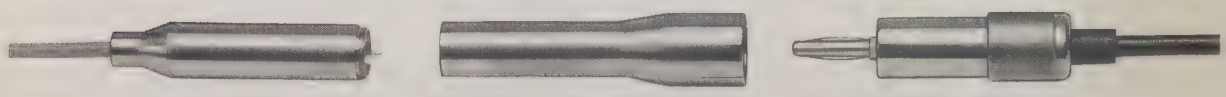


Fig.3.5. Connecting an external signal source to the Preamplifier using special adaptor JJ 2614

3.4. CONNECTING THE EXCITATION SOURCE

Connection of the signal from the external generator to the excitation source is via the socket labelled OUTPUT on the rear panel of the instrument.

The corresponding 4-pin DIN plug of the output cable is secured by a threaded locking ring. The pin connections are shown in Fig.3.6.

The external source of excitation may be a loudspeaker, for example that in the Anechoic Test Chamber Type 4222 for testing the performance of hearing aids, a small vibrator, e.g. for testing bone vibrators, or a telephone or headphone earpiece.

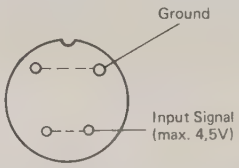


Fig.3.6. Pin connections of the OUTPUT socket viewed looking into the socket or from the soldering side of the corresponding plug

3.5. MOUNTING THE PEN

The 2116 uses a fibre pen which is mounted as follows:

1. At the end of the writing arm is a plastic holder. (See Fig.3.7.) If a pen is already mounted, slide it off the end of the pen holder gently but firmly, while holding the writing arm in position at the top of its travel.

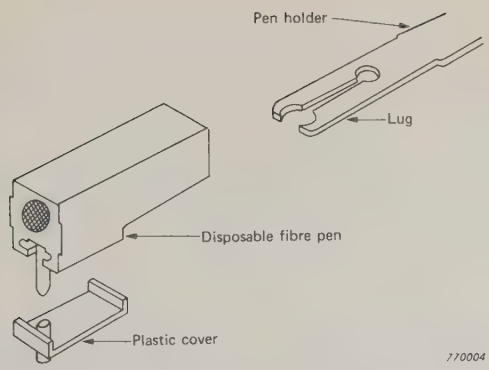


Fig.3.7. Mounting the pen

2. Remove the new pen's plastic cover, which keeps the fibre tip moist and should always be replaced when not in use. Pierce the paper disc at the rear of the pen with a pin to initiate the ink flow.

3. Slide on the new pen, ensuring that its grooves are firmly engaged in the lugs of the pen holder, until the pen clicks securely into position.

4. OPERATION

4.1. INTRODUCTION

The Type 2116 has been designed primarily as a combined Generator / Analyzer / Recorder with a built-in memory which is used to regulate the generator output level automatically in order to provide a constant, known excitation level to which the response of the test object can be measured. In addition, the instrument may be used without automatic regulation of the output signal to supply a constant voltage to a test object, e.g. when measuring the characteristics of telephone / headphone earpieces or bone vibrators. It may also be used without the generator to analyze an external signal, e.g. noise or vibration. The three basic methods of operation are shown diagrammatically in Fig.4.1.

To make use of the internal digital memory to regulate the test environment automatically, the instrument must be operated with the COMPRESSION slider switch on the rear panel in the "In" position and a correction curve recorded first. When not using this automatic level regulation facility, the switch should be in the "Out" position.

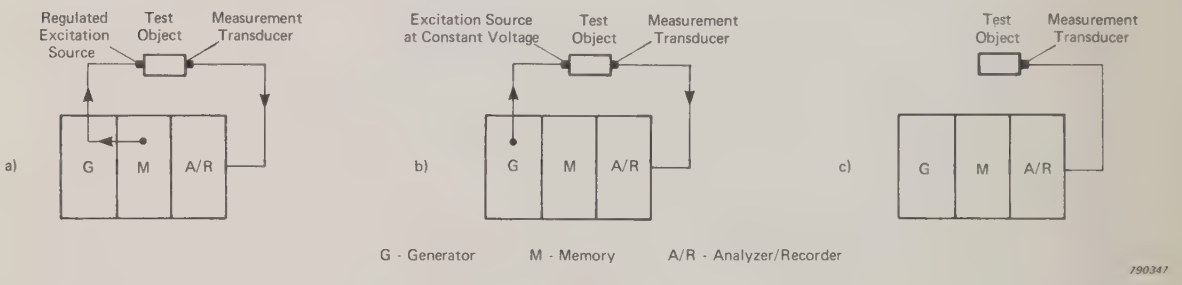


Fig.4.1. The three basic methods of operation of the Type 2116
a) using internal memory to regulate test environment via the generator section
b) without using the internal memory. Generator section supplies constant voltage to test object
c) without using memory or generator section to analyze and record an external signal

4.2. CALIBRATION

General

Carry out all the preliminary adjustments necessary as in Section 3.

It is recommended that a calibration check is carried out before and after each period of use. It is good practice to make a routine of calibrating each time the instrument is switched on, and is of course a necessity if the transducer used is changed.

4.2.1. Direct Acoustic Calibration using Calibrator or Pistonphone

The protection grid must be in place over the microphone diaphragm. Either a Sound Level Calibrator Type 4230, which produces a 94 ±0,25 dB (Re 20×10^{-6} Pa) pure tone at 1000 Hz, or a Pistonphone Type 4220 can be used. When using the Pistonphone the calibration level will vary slightly with ambient atmospheric pressure from its nominal 124 dB value. The 2116 must be calibrated taking account of this factor, which can be found from the barometer and chart delivered with the Pistonphone.

The instrument is calibrated as follows:

1. Insert the microphone into the cavity of the Calibrator (or Pistonphone), using the plastic adaptor DB 0311 in the case of a half inch Microphone, and press gently onto the seating ring so that a good flush fit is obtained.

2. Switch on the Calibrator (or Pistonphone), place a chart on the chart bed of the 2116, and press the CALIBRATE pushkey on the right-hand side of the operating panel.

   The LED in the CALIBRATE pushkey should light and the pen should move down the left-hand margin of the chart to the marked calibration position, 94 dB when using the Sound Level Calibration or 124 dB (Nominal) when using the Pistonphone.

3. Using a small screwdriver, adjust the potentiometer to the right of the CALIBRATE switch so that the pen lies exactly on the calibration mark.

4. Press RETURN and the CALIBRATE again to check that the adjustment is correct. This ensures that the calibration level is always approached from the same direction and also avoids errors which could arise if the pen arm is moved without passing through the standby position, e.g. when changing pens.

The instrument is now calibrated and ready for use.

4.2.2. Direct Vibration Calibration using Accelerometer Calibrator Type 4291

Fig.4.2. The Type 4291 Accelerometer Calibrator

The Accelerometer Calibrator Type 4291 is a small vibration exciter driven by a built-in generator and powered by internal batteries. See Fig.4.2.

The Accelerometer to be calibrated is fixed to the instrument's vibrating table, which can be adjusted to vibrate the accelerometer at 500 rads. sec^{-1} (79,6 Hz) with a level of 10 m. sec^{-2} (peak sinewave value).

The procedure is as follows:

1. Connect the accelerometer cable to the Preamplifier Type 2642 using the adaptor JJ 2615 as in Section 3.3.2. Ensure that the Preamplifier is plugged into the INPUT socket of the 2116.

2. Ascertain the mass of the Accelerometer from its calibration chart.

3. Mount the Accelerometer (finger-tight is sufficient) to the table by means of a 10—32 UNF stud. For accelerometers having a 3 mm stud, use the 3 mm-to-10-32 UNF adaptor (DB 1425). For accelerometers not having a stud or tapped hole, use the cementing stud (DB 0756) and wax or cement.

4. If the internal battery supply of the 4291 is to be used, switch the FUNCTION SELECTOR to "Batt. Check". If the METER deflection falls outside the green "BATT." mark, replace the batteries.

5. Switch the FUNCTION SELECTOR to "Internal Gen." The Calibrator will now vibrate the accelerometer at 79,6 Hz (i.e. 500 radians/second).

6. Adjust the ACC. LEVEL control until the METER pointer coincides with the load mass on the "0 ... 100 gram" scale. The load mass is the total mass attached to the vibration system, usually the accelerometer to be calibrated and the mounting-stud (the latter is generally negligible). The accelerometer is now subjected to a sinusoidal acceleration of 10,0 ms^{-2} peak ±2%.

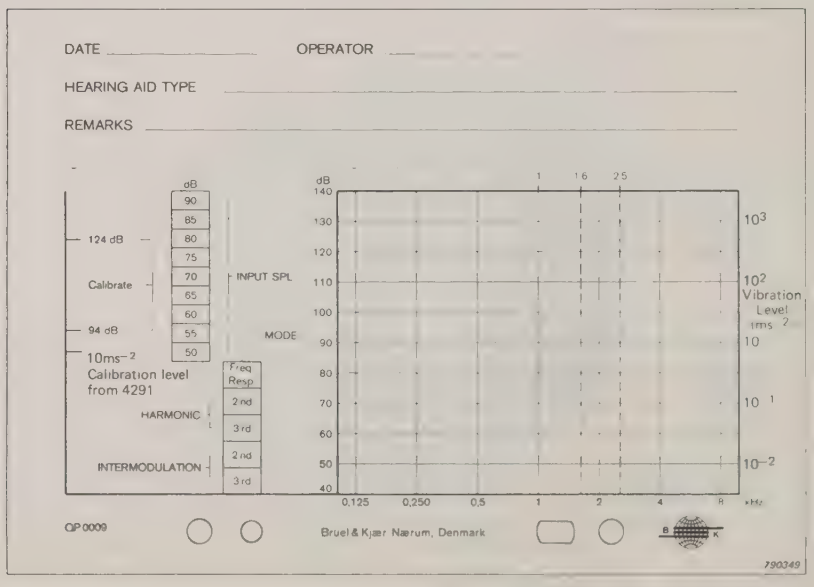


Fig.4.3. Direct vibration calibration of the recording chart in ms^{-2} using Accelerometer Calibrator Type 4291

7. Press the CALIBRATE pushkey on the control panel of the 2116. The LED should light, showing that the instrument is in CALIBRATE mode and the pen will move down the left-hand margin of the paper.

8. Using a small screwdriver adjust the potentiometer to the right of the CALIBRATE pushkey so that the pen lies 3 dB below any of the horizontal lines on the paper. The 3 dB occurs because the output of the Calibrator is 10 ms^{-2} **peak** i.e. 7,07 ms^{-2} RMS, 3 dB below 10 ms^{-2} RMS. See Fig.4.3.

9. Label the chosen line 10 ms^{-2} and the rest of the scale as shown in Fig.4.3.

4.2.3. Direct Voltage Calibration using an External Signal Generator

This method may be used to calibrate for any transducer whose voltage sensitivity is known e.g. microphones, accelerometers, hydrophones, force transducers etc. An external source capable of supplying a known voltage within the 100 Hz to 10 kHz range of the 2116, such as the Type 1023 Sine Generator, is required. The procedure is as follows:

1. Connect the Preamplifier Type 2642 to the output of the Signal Generator as in Section 3.3.3.

2. Set the frequency of the Sine Generator to within the frequency range of the 2116 i.e. 100 Hz to 10kHz.

3. Set the output to a suitable level e.g. a convenient round figure, say 10 mV rms.

4. Press CALIBRATE on the 2116. The pen will move down the left-hand margin of the paper and should be adjusted level with a convenient line by means of the CALIBRATE potentiometer.

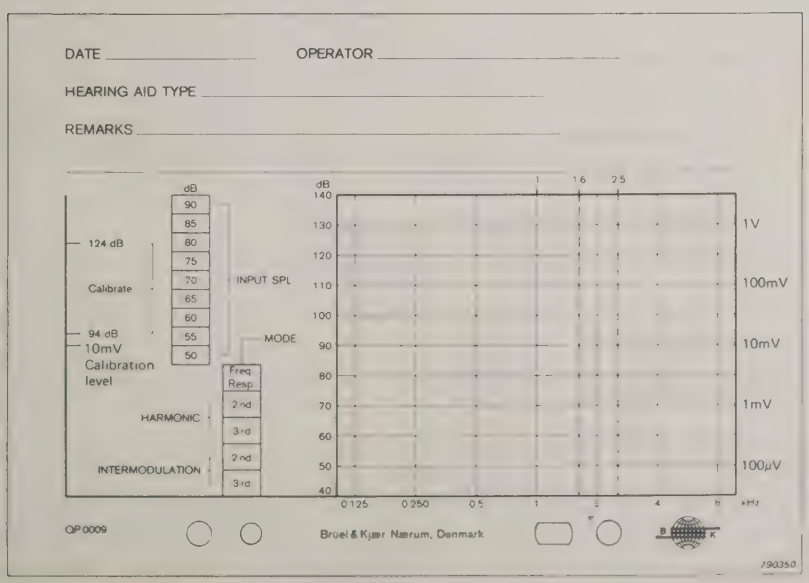


Fig.4.4. Direct voltage calibration of the 2116 using an external signal generator

5. Label this line with the Sine Generator output level, i.e. 10 mV in the example here, and the other lines as shown in Fig.4.4. Every 2nd line on the recording paper corresponds to a factor of 10 (20 dB).

4.2.4. Indirect Calibration of Transducers using an External Sine Generator

It is recommended that a measuring set-up be calibrated directly using a calibrated excitation source, e.g. Sound Level Calibrator, wherever possible as this method calibrates the entire measuring chain, as used, including the transducer and connecting leads. However, if it is found necessary to use on indirect calibration method, this may be carried out as follows:

1. Connect the Preamplifier Type 2642 to the output of the Signal Generator as in Section 3.3.3.

2. Set the frequency of the Sine Generator to within the frequency range of the 2116 i.e. 100 Hz to 10 kHz.

3. Set the voltage output of the Sine Generator to the sensitivity of the transducer to be used. Every B & K microphone, accelerometer, or other transducer is delivered with an individual calibration chart quoting its sensitivity in relevant units.

4. Press CALIBRATE on the 2116 so that the pen indicates the input level at the left margin of the chart.

5. The calibration potentiometer is now adjusted to place the pen conveniently on the chart. This procedure is slightly different for microphones than for accelerometers or other transducers.

   a. Accelerometer voltage sensitivities are normally given in mV/g or mV/ms^{-2}, the units in which vibration is normally expressed. The pen can therefore be adjusted on a line which can then be labelled with the relevant unit i.e. 1 g or 1 ms^{-2}.

   b. Microphone sensitivities are usually expressed in mV/Pa (1 Pa = 94 dB), so in this case the pen should be positioned 4 dB above a convenient line. In the case of microphone sensitivities between 8 and 80 mV/Pa, the range of the CALIBRATION potentiometer enables the pen to be positioned on the 94 dB mark. For other sensitivities the scale must be renumbered accordingly.

The chart paper is now calibrated.

4.3. GENERAL OPERATING PROCEDURE

Carry out all the necessary adjustments as in Section 3 and calibrate the measuring system as in Section 4.2.

The test procedure varies slightly depending on whether or not a correction curve is required to maintain a constant test environment. If this facility is required, the correction curve must be recorded in the instrument's memory before any measurements can be carried out. To do this the rear panel slider switch labelled COMPRESSION must be in the "In" position. When making measurements at constant voltage, this switch must be in the "Out" position.

4.3.1. Recording the Correction Curve

1. Connect the transducer which is measuring the parameter are to be stored and subsequently compensated for. Ensure that the COMPRESSION switch is in the "In" position.

2. Press the two READ IN pushkeys simultaneously, the left-hand one first.

The pen will move along the top of the chart from its stand-by position and come to rest at the beginning of the frequency scale. An output level, which corresponds to the nominal 90 dB sound pressure level indicated on the front panel, is selected automatically and the 90 dB SPL LED and those in the READ IN pushkeys should now come on. After about 10 seconds, during which time the output level rises until it corresponds to the selected level, the frequency sweep begins at 100 Hz and continues in 256 discrete steps at 1,8% intervals up to 10 kHz. At each frequency step the output level is regulated in 0,3 dB steps until it is equal to the nominal value, and the correction required to achieve this is stored in the memory of the 2116. During this process the pen remains raised but follows the current frequency along the top of the chart to indicate how far the process has progressed. When 10 kHz is reached, the pen returns to the stand-by position, the LEDs on both READ-IN pushkeys extinguish, and the pilot lamp in the RETURN switch lights.

If the CONTINUE switch on the rear panel is pressed during the READ-IN process, no valid correction curve will be recorded from that point in the frequency sweep until it is released again. Subsequent test sweeps will only be valid for those parts of the test sweep for which the switch was released. This facility may be useful where tests are to be carried out on a test object whose response dynamic range is known to be too large, or whose normal working frequency range is less than that of the Type 2116. In the latter case levels may occur, because of resonances, or high cut-off rates at the limits of the test object's normal frequency range, which lie outside the correction dynamic range of the 2116.

If the RETURN pushkey is operated during READ IN, the process is terminated at that frequency and the pen is returned to the stand-by position. Any subsequent test sweeps will also be terminated at that frequency. These two switches enable the operator to choose the frequency range over which the test is made. All other switches are inoperative during READ IN.

4.3.2. Performing the Measurement

1. Mount the measurement transducer on the Preamplifier Type 2642 using an adaptor where necessary as described in Section 3.3 and connect the miniature plug to the INPUT socket on the rear panel of the instrument.

2. Select the required measurement parameter using the TEST MODE switch, and if performing a distortion measurement select the required order using the DISTORTION ORDER switch.

3. If the internal generator is to be used to supply either a regulated test environment or a constant voltage level, select the required test level using the pushkeys UP and DOWN until the desired test level is indicated on the row of light emitting diodes.

4. Press RUN to begin the measurement sweep. The LED in the switch will light and the pen will indicate the selected measurement parameter and level before performing the sweep. When the sweep is completed, the RUN LED extinguishes, the RETURN LED lights, and then the pen is returned to its stand-by position.

The measurement may be halted temporarily at any time by pressing STOP. Pressing RUN continues the sweep. Pressing RETURN at any time ends the sweep and returns the pen to its stand-by position. When operating in INTERMOD mode, the 2^{nd}, higher frequency generator, can be stopped temporarily by pressing G2 STOP, preferably after stopping the frequency sweep by first pressing STOP. This enables the operator to check that it is indeed an intermodulation product which is being measured and not circuit noise. The indicated level should drop by at least 10 dB to ensure valid measurements.

5. USE WITH OTHER TEST APPARATUS

5.1. USE WITH THE ANECHOIC TEST CHAMBER TYPE 4222 FOR HEARING AID AND MICROPHONE TESTING

These procedures are described in detail in the manual for the Anechoic Test Chamber Type 4222 to which reference should be made.

5.2. USE WITH THE ARTIFICIAL EARS TYPES 4152 AND 4153 FOR MEASUREMENTS ON EARPHONES

The 2116, having both a sine generator and an analyzer built in, is especially suitable for measurements which require an excitation source, such as telephone or headphone measurements, using either of the Artificial Ears Types 4152 and 4153. The Type 4153 Artificial Ear is designed to be used with the 1/2'' Microphone Type 4134 and meets the requirements of IEC R 318. The Type 4152 is designed to be used with the 1'' Microphone Type 4144 and may be fitted with a range of couplers for measurements on earphones or headphones. The procedures for use with the 2116 are generally similar for both types, and only the use of the Type 4153 is described here. Firstly, calibrate the 2116, preferably directly with an acoustic calibrator or pistonphone, as in Section 4.2.1.

A sectional view of the Artificial Ear Type 4153 is shown in Fig.5.1.

To prepare the Artificial Ear for use proceed as follows:

1. Unscrew the Coupler.

2. Screw the Microphone Cartridge, with its protective grill removed, to the microphone socket.

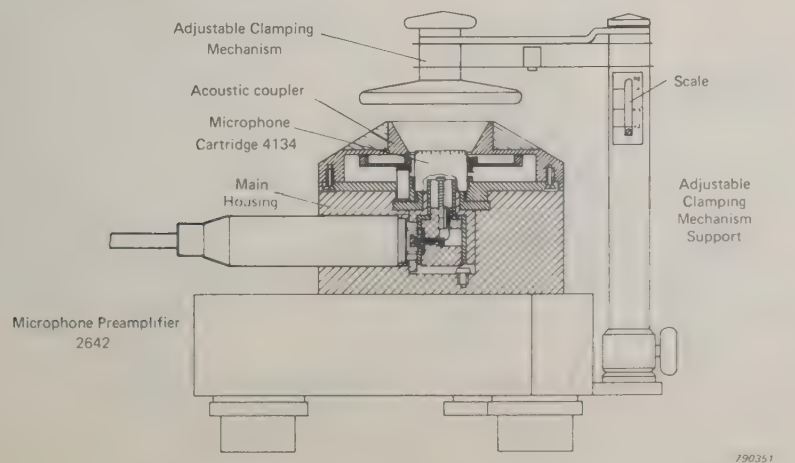


Fig.5.1. Sectional view of the Artificial Ear Type 4153

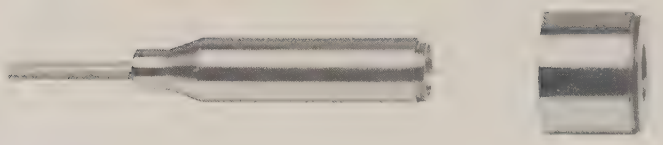


Fig.5.2. Adaptor DB 0962 to enable 1/2" Preamplifier Type 2642 to be connected to the Artificial Ear Type 4152, which employs a one inch Microphone

NOTE: Take great care not to touch the diaphragm.

3. Replace the Coupler on the Coupler Socket.

4. Screw the Preamplifier Type 2642 into the socket in the body of the Artificial Ear.

   When using the Type 2642 Preamplifier with the Artificial Ear Type 4152, which has a 1" preamplifier fitting, adaptor DB 0962, see Fig.5.2, should be used.

5. For testing normal (i.e. supra-aural) headphones: place the Adaptor YJ 0304 on top of the Coupler. It is possible to invert or remove the Adaptor to accommodate particular headphones but if this be done it should be mentioned in the test specifications.

   For testing circumaural headphones: place the Adaptor DB 0843 on top of the Coupler. The Adaptor YJ 0304 may be placed on top of this arrangement to simulate the human pinna. The Adaptor YJ 0304 may be either upright or inverted and the orientation chosen should be mentioned in the test specifications. The Clamping Mechanism cannot be used with the Adaptor DB 0843.

6. Place the headphone to be tested on top of the Artificial Ear.

7. If one wishes to apply a force to the headphone proceed as follows:

   Supra-aural headphones: mount the Clamping Mechanism on the base of the Artificial Ear then adjust the height of mechanism until the desired force is indicated on the engraved scale.

Fig.5.3 Left) Adaptor DB 0843 mounted on the Artificial Ear Type 4153 (the clamping mechanism and the Adaptor YJ 0304 have been removed)
Right) A circumaural sound attenuating cup mounted on the Artificial Ear

Circumaural headphones: use weights to provide the desired force but do not exceed 10 N (1 kg force).

8. Connect the signal from the OUTPUT socket on the rear panel of the 2116 (See pin diagram Fig.3.2) to the external excitation source.

9. Ensure that COMPRESSION switch is in "Out" position, so that a constant voltage output is obtained, and that the preamplifier is connected to the INPUT.

10. Select a suitable output level using the SPL dB UP and DOWN pushkeys. An output range of 40 dB, from 2,5 to 250 mV (nominal), in 5 dB steps, is available.

11. Select the required measurement parameter and press RUN to start the measurement. Its LED will come on, and the one in the pushkey beside it will continue to flash to indicate that the instrument is operating in the COMPRESSION "Out" mode, supplying a constant output voltage withtout reference to a stored correction curve. A typical telephone earphone frequency response to a constant voltage input is reproduced in Section 1 Fig.9.

5.3. USE WITH THE ARTIFICIAL MASTOID TYPE 4930 FOR MEASUREMENTS ON BONE CONDUCTORS

The Audio Test Station Type 2116 can be advantageously used with the Artificial Mastoid for frequency response and distortion measurements on bone conductors. The generator section supplies a suitable test signal to the bone conductor and the analyzer section analyses the signal from the force transducer built into the Artificial Mastoid. The measuring set-up is simple and the measuring process straightforward.

A direct voltage calibration should be used as in Section 4.2.3. Reference may then be made to the calibration chart delivered with the Type 4930 Artificial Mastoid. A diagram of the instrument is shown in Fig.5.4.

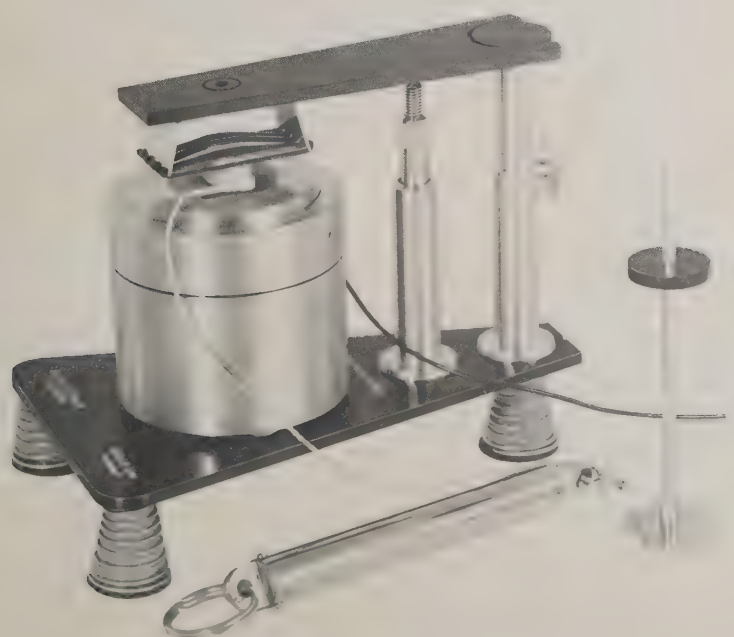


Fig.5.4. The Artificial Mastoid Type 4930

The procedure for setting up and calibrating the instrumentation is as follows. For detailed information about setting up the Artificial Mastoid please refer to its Instruction Manual.

1. Connect the output of the Force Transducer of the Artificial Mastoid to the preamplifier Type 2642 using the cable supplied with the Mastoid. An adaptor JJ 2615 is required to connect the mini plug of the transducer cable to the half-inch preamplifier.

2. Connect the preamplifier to the INPUT socket on the rear panel of the Audio Test Station.

3. Connect the bone conductor to the OUTPUT socket on the rear panel of the 2116. The pin connection diagram is shown in Fig.3.2.

4. Place the bone conductor on the calibration surface of the Artificial Mastoid and adjust the preload to the required value as described in detail in the manual for the Artificial Mastoid.

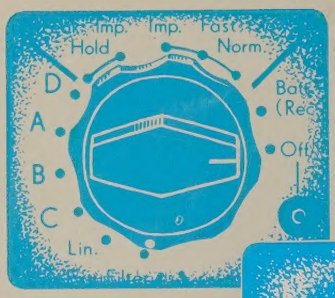
5. Ensure that the COMPRESSION switch on the rear panel of the 2116 is in the "Out" position so that a constant voltage output is obtained.

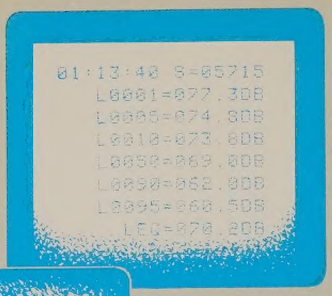
6. Select a suitable output level using the SPL UP and DOWN pushkeys.

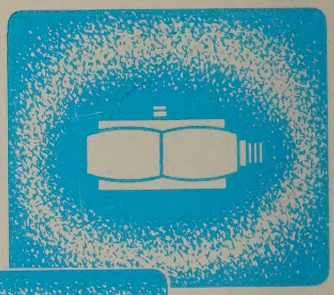
7. Select the required measurement parameter and press RUN to start the measurement.

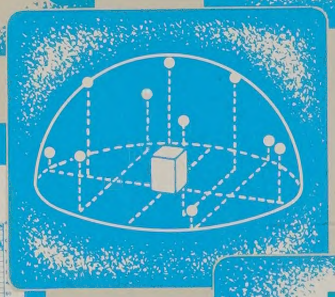
6. SERVICE AND REPAIR

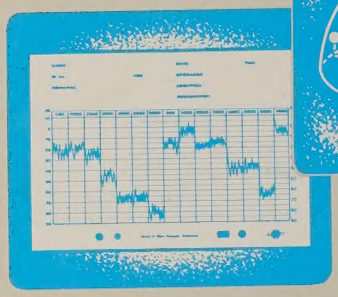
The Type 2116 is designed and constructed to provide the user with many years of safe, trouble free operation. However, should a fault occur which impairs its correct function and operating safety, then it should be immediately disconnected at the mains source and be secured against unintended operation. For repair consult the separate Service Instruction Manual available for the Type 2116 or contact your local B & K service representative. Under no circumstances should repair be attempted by persons not qualified in the service of electronic instrumentation.

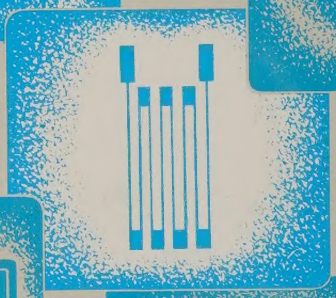


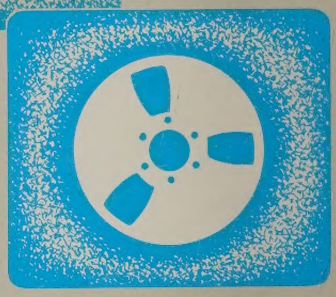


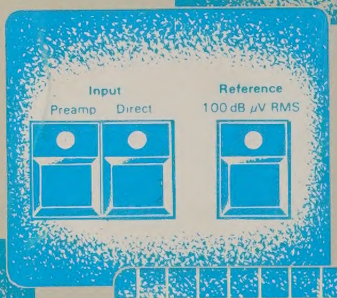


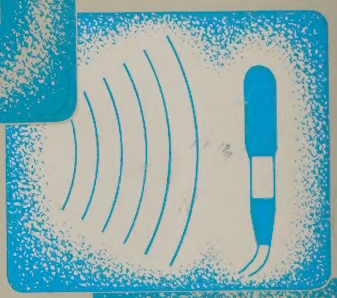


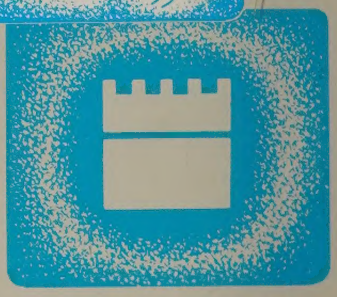


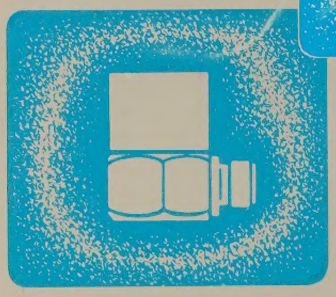


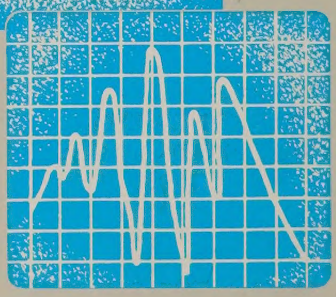


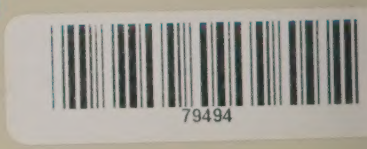












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